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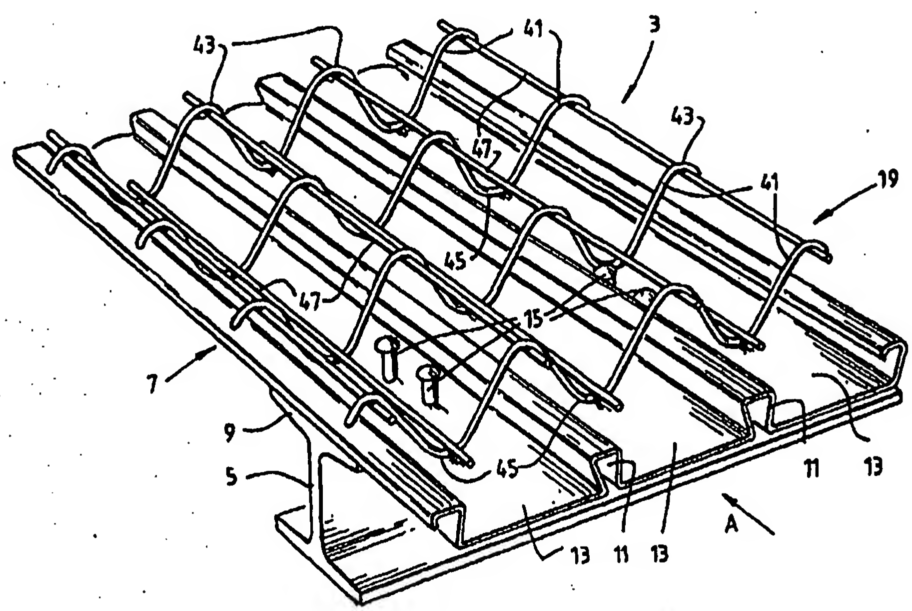

(57) Abstract

A composite beam (3) for the building industry is disclosed. The composite beam (3) comprises: a horizontally extending beam (5); a composite slab formed from profiled sheeting (7) and concrete cast on the sheeting (7); a plurality of shear connectors (15) extending through the sheeting (7) and welded to the top flange (9) of the beam (5); and a reinforcing component (19) in the concrete slab for preventing premature longitudinal shear failure of the composite beam (3).

A COMPOSITE BEAM

The present invention relates to composite beams for the building industry.

The term "composite beam" is understood herein to mean a beam, preferably formed from steel, and a solid or composite slab interconnected by shear connection to act together to resist action effects as a single structural member.

The term "shear connection" is understood herein to mean an interconnection between a beam and a solid or composite slab of a composite beam which enables the two components to act together as a single structural member.

In conventional composite beams, typically, the shear connection comprises shear connectors, slab concrete, and transverse reinforcement.

The term "shear connector" is understood herein to mean a mechanical device attached to the top flange of a steel beam which forms part of the shear connection.

In particular, the present invention relates to composite beams of the type comprising:

(a) a horizontal beam (typically steel) supported at each end;

(b) a composite slab positioned on and supported by the steel beam and comprising:

(i) profiled metal (typically steel) sheeting,

(ii) concrete cast on the sheeting, and

(iii) reinforcement embedded in the concrete; and

(c) a plurality of shear connectors, typically in the form of headed studs, embedded in the concrete and extending through the sheeting and welded to the top flange of the beam thereby to connect the composite slab to the beam.

The present invention is concerned particularly with reinforcing the type of composite beams described above so that the composite beams have sufficient longitudinal shear capacity for the longitudinal forces arising from compressive stresses that develop across its width and within its depth to be transferred to the shear connectors and thereby to prevent premature longitudinal shear failure of the composite beams.

The conventional reinforcement for preventing longitudinal shear failure in the type of composite beams described above comprises deformed reinforcing bars or welded wire fabric embedded in a horizontal position in the concrete of the composite slab. The reinforcement is arranged to extend transversely to the longitudinal axis of the composite beam and therefore crosses potential longitudinal shear surfaces and by this mechanism is thought to contribute to the longitudinal shear capacity of the composite slab.

However, in research carried out by the applicant on the type of composite beams described above it was found that the composite beams tested, which included such conventional horizontal reinforcement, failed prematurely by longitudinal shear failure by a mechanism of horizontal

splitting along the line of shear connectors in the composite slab.

The research was carried out on composite beams formed from profiled steel sheeting comprising open steel ribs separated by pans. The profiled steel sheeting was positioned so that the steel ribs extended transversely to the longitudinal axis of each steel beam. An edge of the composite slab of each composite beam was positioned to run parallel to the top flange of a steel beam, as occurs for perimeter beams. As indicated above, the composite beams also comprised conventional horizontal reinforcement with bars laid transversely to the longitudinal axis of each of the steel beams. The composite beams were loaded by applying a downward force.

It was found that horizontal splits formed in the concrete between the tops of the steel ribs of the profiled steel sheeting that were adjacent to the pans in which the shear connectors were positioned. Part of the compressive force in the concrete slab arising from the flexural action of the composite beam was directed across the horizontal plane through the tops of the steel ribs wherever shear connectors occurred. Therefore, at these locations the steel ribs presented a source of weakness to the composite beam. However, at pans without shear connectors, no shear force was transmitted across the horizontal plane through the tops of the steel ribs and the splits did not form.

It was also found that the horizontal splits locally avoided the shear connectors by passing over the tops of the shear connectors.

It was also found that longitudinal slip between a concrete slab and a steel beam of the order of only 1mm was necessary before the shear connection failed suddenly, which was entirely unsatisfactory since such failures are

difficult to design against, and also the shear capacity of the shear connectors is significantly underutilised.

In addition, it was found that the conventional horizontal reinforcement, which was thought should prevent premature longitudinal shear failure, appeared to assist in initiating the horizontal splits and therefore was also entirely unsatisfactory on this basis.

An object of the present invention is to provide a composite beam with improved resistance to longitudinal shear failure of the type described in the preceding paragraphs.

According to the present invention there is provided a composite beam comprising:

(a) a beam;

(b) a composite slab positioned on the beam, the composite slab comprising:

(i) profiled sheeting having a plurality of pans separated by ribs, the profiled sheeting being positioned so that the ribs extend transversely to the longitudinal axis of the beam;

(ii) concrete cast on the profiled sheeting;

(c) a plurality of shear connectors which connect the composite slab to the beam; and

(d) a reinforcing component embedded in the concrete slab, the reinforcing component

having a reinforcing element that extends through an imaginary horizontal plane that passes through the tops of the ribs of the profiled sheeting to prevent premature longitudinal shear failure of the composite beam.

The applicant has found that the reinforcing component described in sub-paragraph (d) above improves dramatically the transfer of horizontal force between the composite slab and the beam of the composite beam.

As a consequence, the present invention makes it possible to avoid premature longitudinal shear failure of the structural composite beam at loads below the load at which the shear connectors have achieved full potential strength.

In addition, as a consequence, the present invention makes it possible to use significantly fewer shear connectors than would otherwise be required.

It is preferred that the beam be a steel beam.

It is preferred that the profiled sheeting be profiled steel sheeting.

It is preferred that the beam be supported at each end.

In one embodiment, it is preferred that the beam be an internal beam.

In another embodiment, it is preferred that the beam be a perimeter beam.

It is preferred that the composite slab further

comprises reinforcement such as welded wire fabric embedded in the concrete of the composite slab.

It is preferred that the shear connectors be headed studs. The shear connectors may be of any other suitable form such as structural bolts or channels.

In one arrangement it is preferred that the reinforcing component comprise welded wire fabric having a series of folds with peaks straddling the ribs and troughs contacting the pans.

With such an arrangement, the reinforcing element comprises the sections of the longitudinal wires or the cross-wires of the welded wire fabric that extend between the peaks and the troughs.

In an alternative arrangement, it is preferred that the reinforcing component be a cage which at least partially encloses one or a group of the shear connectors in a pan.

With such an arrangement, the reinforcing element comprises the upright sections of the cage.

In one embodiment, it is preferred that the cage be formed from deformed reinforcing bars.

In another embodiment, it is preferred that the cage be formed from welded wire fabric.

The present invention is described further by way of example with reference to the accompanying drawings in which:

Figure 1 is a perspective view which illustrates, in simplified form, a preferred embodiment of a composite

beam in accordance with the present invention;

Figure 2 is an elevation of the composite beam shown in Figure 1 in the direction of the arrow A in Figure 1;

Figure 3 is a perspective view of the reinforcing component of the preferred embodiment of the composite beam in accordance with the present invention that is shown in Figures 1 and 2;

Figure 4 is a perspective view of the reinforcement component of another preferred embodiment of a composite beam in accordance with the present invention;

Figure 5 is a perspective view of the reinforcing component of another preferred embodiment of a composite beam in accordance with the present invention;

Figure 6 is a perspective view which illustrates, in simplified form, another preferred embodiment of a composite beam in accordance with the present invention; and

Figure 7 is a perspective view of the reinforcing component of the preferred embodiment of the composite beam in accordance with the present invention that is shown in Figure 6.

The preferred embodiment of the composite beam 3 in accordance with the present invention that is shown in Figures 1 to 3 is in a simplified form to illustrate the composite beam 3 more clearly.

With reference to the figures, the composite beam 3 comprises:

(a) a horizontally extending hot-rolled or fabricated steel beam 5 which is supported at each end;

(b) a composite slab comprising:

(i) profiled steel sheeting 7 in contact with the top flange 9 of the steel beam 5, the sheeting 7 comprising a plurality of parallel steel ribs 11 separated by pans 13 and positioned so that the ribs 11 extend in a direction that is transverse to the longitudinal axis of the beam 5; and

(ii) concrete (not shown) cast on the sheeting 7;

(c) a plurality of shear connectors 15 in the form of headed studs which extend through the sheeting 7 and are welded to the top flange 9 of the beam 5; and

(d) a reinforcing component 19 in the concrete slab for preventing premature longitudinal shear failure of the composite beam 3.

The beam 5 and the composite slab may be of any suitable dimensions and construction. Typically, the composite slab has a thickness of at least 120mm. In addition, whilst the sheeting 7 shown in Figures 1 and 2 has a dovetail profile, the sheeting 7 may be trapezoidal of any other suitable shape.

The reinforcing component 19 is formed by bending the longitudinal wires 41 of a piece of welded wire fabric to form, as can best be seen in Figure 2, a series of

folds.

In the preferred embodiment shown in Figures 1 to 3, the reinforcing component 19 is positioned so that the longitudinal wires 41 extend transversely to the ribs 11 with peaks 43 straddling the ribs 11 and troughs 45 contacting the pans 13 of the sheeting 7. With this arrangement, the cross-wires 47 of the welded wire fabric extend parallel to the ribs 11 of the sheeting 7.

The welded wire fabric may be of any suitable dimensions and construction. Typically, the welded wire fabric is formed from deformed wire having a diameter of 6 - 8mm with a spacing of 150mm between the 4 longitudinal wires 41 of the welded wire fabric - thus making 450mm the nominal overall width of the reinforcing component 19. Typically, 600 - 1800mm is the nominal overall length of the reinforcing component 19.

When a structural composite beam 3 of the basic type shown in the Figures 1 to 3 is loaded, longitudinal slip is induced between the composite slab and the steel beam 5 which is resisted by the shear connection between these components.

In a conventional structural composite beam (without the reinforcing component 19) the shear connection comprises:

(a) the shear connectors 15;

(b) concrete cast in a slab; and

(c) conventional horizontal reinforcement in the vicinity of the shear connectors 15.

The shear connection also comprises the sheeting

7 if the sheeting is attached by some means to the steel beam 5, for example by puddle welds.

However, in accordance with the present invention, the shear connection also comprises the reinforcing component 19 as shown by way of example in Figures 1 to 3.

The reinforcing component 19 is designed to specifically prevent premature longitudinal shear failure and, in particular, premature longitudinal shear failure caused by a mechanism of splitting of the composite slab in a horizontal plane across the tops of the steel ribs 11, as well as by other mechanisms.

In general terms, the reinforcing component 19 is designed to improve the transfer of horizontal forces between the composite slab and the steel beam 5. In research work carried out by the applicant the reinforcing component 19 shown in Figures 1 to 3 has been found to be effective in achieving this objective.

Figures 4 and 5 illustrate two alternative constructions of the reinforcing component 19. These forms of the reinforcing component 19 are similar to that shown in Figures 1 to 3. Specifically, the reinforcing components 19 are formed by bending the longitudinal wires 41 of welded wire fabric. However, unlike the reinforcing component 19 shown in Figures 1 to 3, the spacing of the cross-wires 47 of the embodiments shown in Figures 4 and 5 is not uniform. In addition, in the case of the reinforcing component 19 shown in Figure 5, the troughs 45 are flat rather than curved.

With reference to Figures 6 and 7, another preferred embodiment of the reinforcing component 19 comprises a "cage" formed from deformed reinforcing bars

which is designed to enclose a group of shear connectors 15 in a pan 11.

The cage comprises two loops 51 of deformed wire which are bent into a U-shaped configuration and are interconnected by parallel deformed reinforcing bars 53. The loops 51 are formed so that the lower sections of the loops 51 can be located in the region of the junction of the ribs 11 and the pan 13.

As with the arrangement shown in Figures 1 to 3, it has been found by the applicant in research work that the use of the reinforcing component 19 as shown in Figures 4 and 5, in conjunction with other structural components which form the shear connection, substantially prevented longitudinal shear failure of composite beams.

Many modifications may be made to the preferred embodiment of the composite beam of the present invention without departing from the spirit and scope of the present invention.

By way of example, whilst the preferred embodiment described in relation to Figures 1 and 3 comprises a beam 5 and a profiled sheeting 7 formed from steel, it can readily be appreciated that the present invention is not so limited and extends to beams 5 and profiled slab soffits formed from any suitable material.

CLAIMS:

1. A composite beam comprising:

(a) a beam;

(b) a composite slab positioned on the beam, the composite slab comprising:

(i) profiled sheeting having a plurality of pans separated by ribs, the profiled sheeting being positioned so that the ribs extend transversely to the longitudinal axis of the beam;

(ii) concrete cast on the profiled sheeting;

(c) a plurality of shear connectors which connect the composite slab to the beam; and

(d) a reinforcing component embedded in the concrete slab, the reinforcing component having a reinforcing element that extends through an imaginary horizontal plane that passes through the tops of the ribs of the profiled sheeting to prevent premature longitudinal shear failure of the composite beam.

2. The composite beam defined in claim 1 wherein the beam is a steel beam.

3. The composite beam defined in claim 1 or claim 2 wherein the profiled sheeting is profiled steel

sheeting.

4. The composite beam defined in any one of the preceding claims wherein the beam is supported at each end.

5. The composite beam defined in any one of the preceding claims wherein the beam is an internal beam.

6. The composite beam defined in any one of claims 1 to 4 wherein the beam is a perimeter beam.

7. The composite beam defined in any one of the preceding claims further comprises a mesh reinforcement embedded in the concrete of the composite slab.

8. The composite slab defined in any one of the preceding claims wherein the shear connectors are headed studs.

9. The composite beam defined in any one of the preceding claims wherein the reinforcing component comprises welded wire fabric having a series of folds with peaks straddling the ribs and troughs contacting the pans.

10. The composite beam defined in claim 9 wherein the reinforcing element comprises the sections of the longitudinal wires or the cross-wires of the welded wire fabric that extend between the peaks and the troughs.

11. The composite beam defined in any one of claims 1 to 9 wherein the reinforcing component comprises a cage which at least partially encloses one or a group of the shear connectors in a pan.

12. The composite beam defined in claim 11 wherein the reinforcing element comprises the upright

sections of the cage.

13. The composite beam defined in claim 12 wherein the cage is formed from deformed reinforcing bars.

14. The composite beam defined in claim 12 wherein the cage is formed from welded wire fabric.

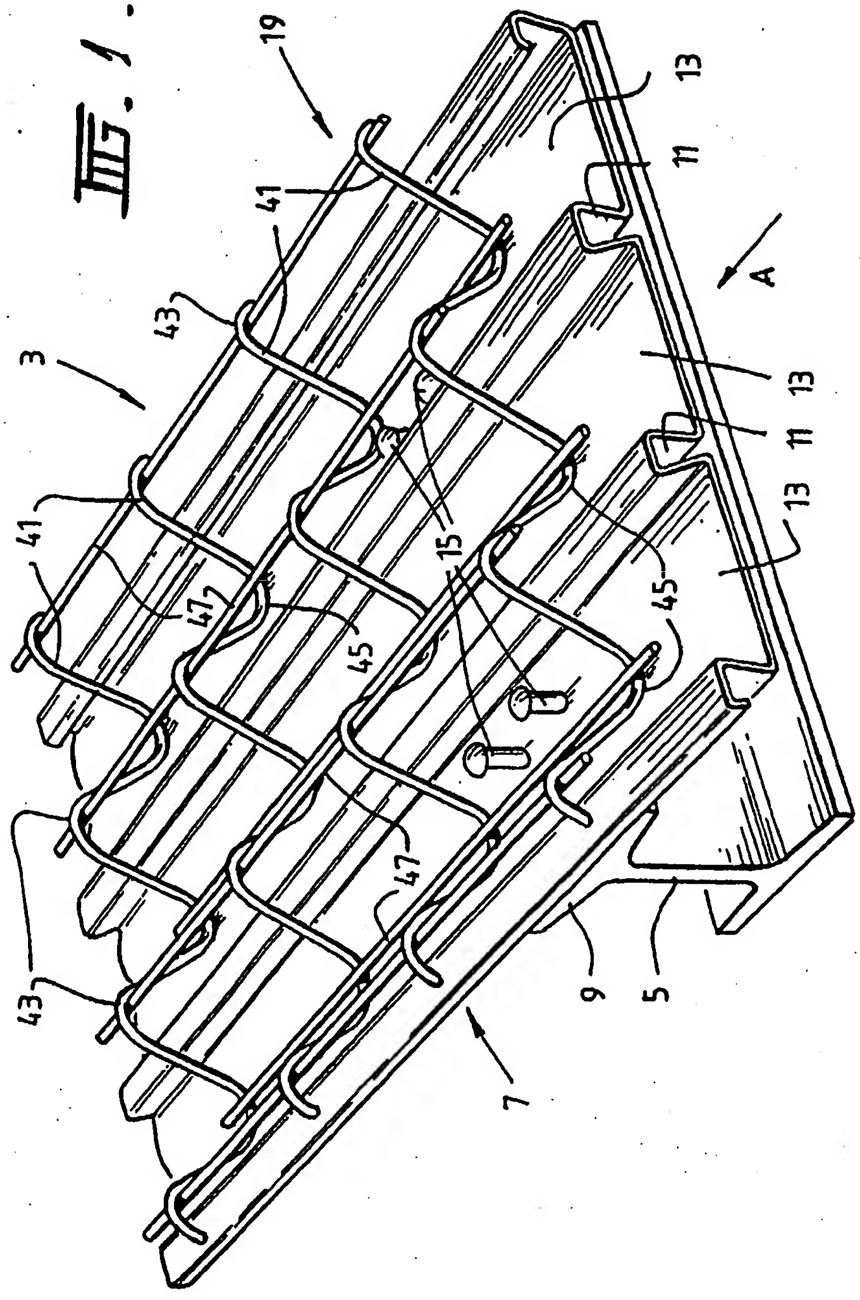

FIG. 1.

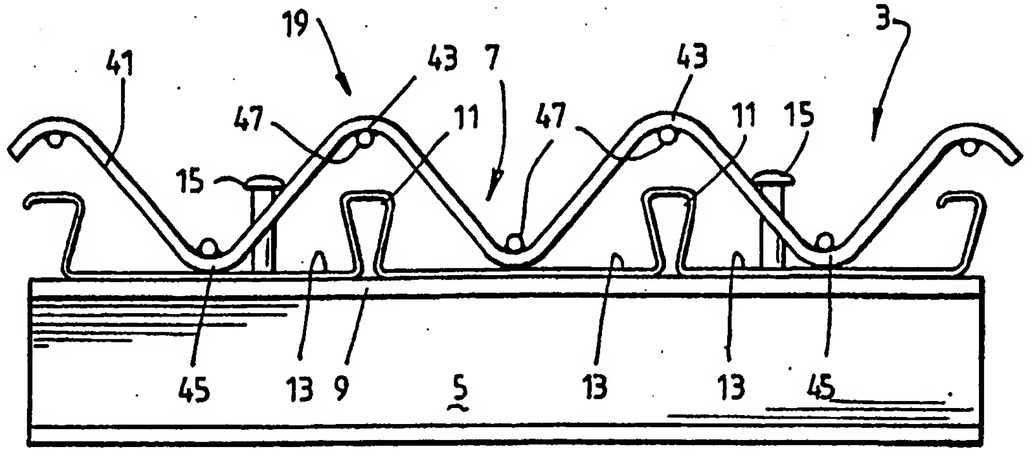
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FIG. 2.

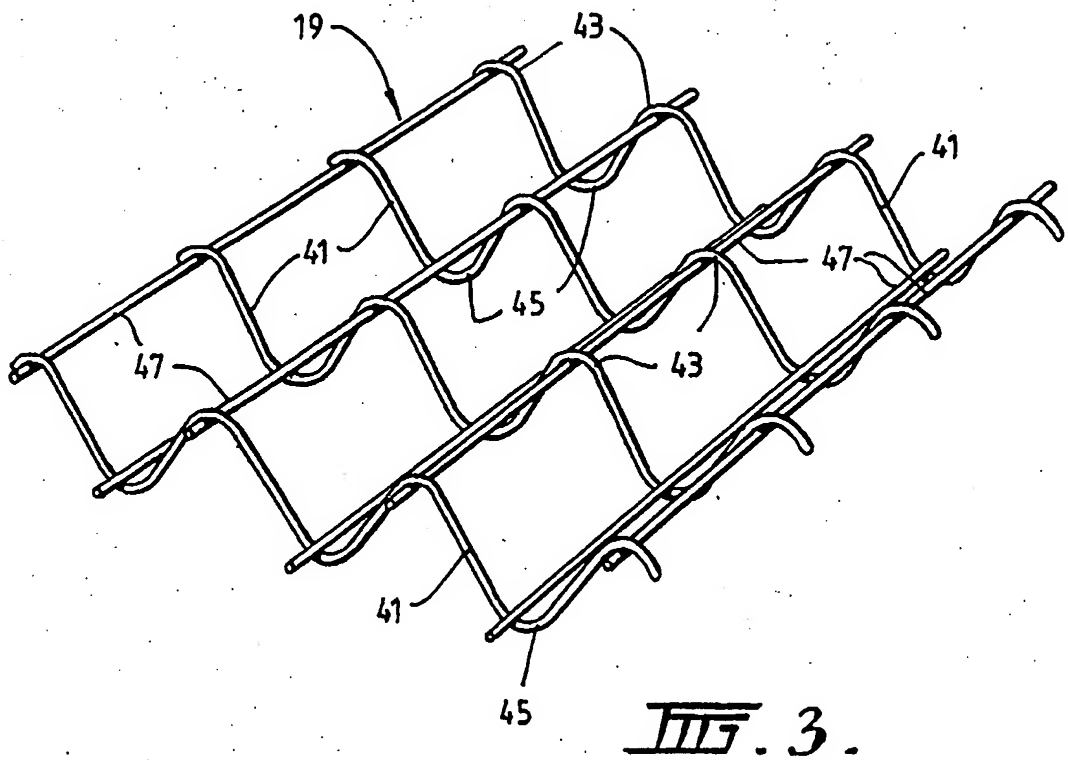
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FIG. 3.

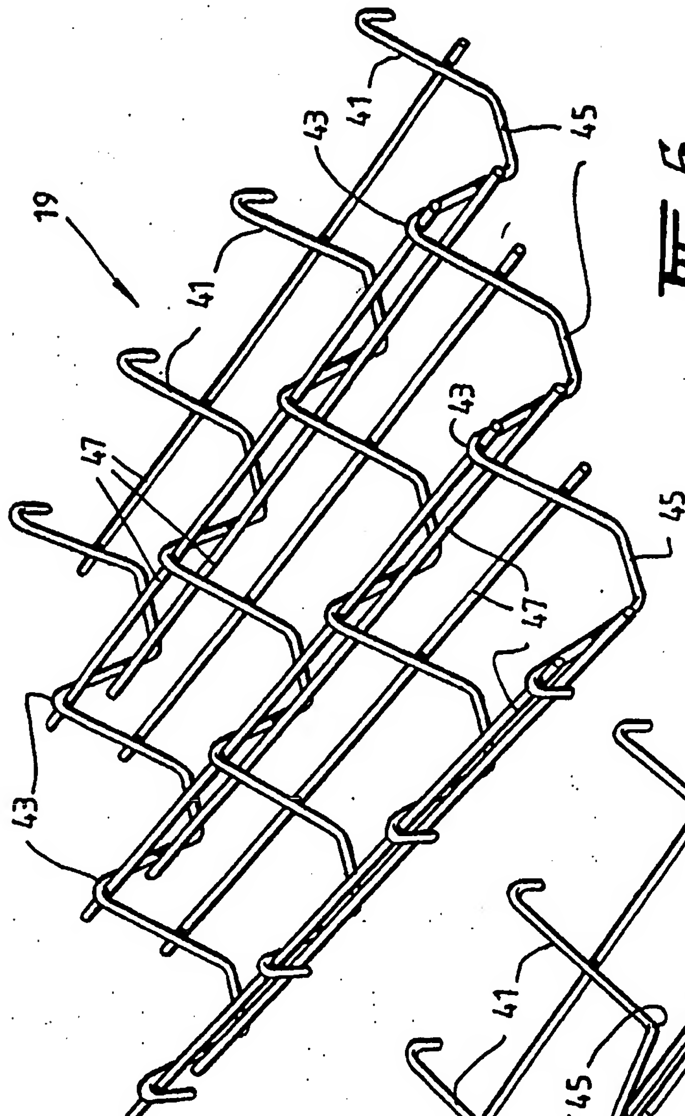
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FIG. 5.

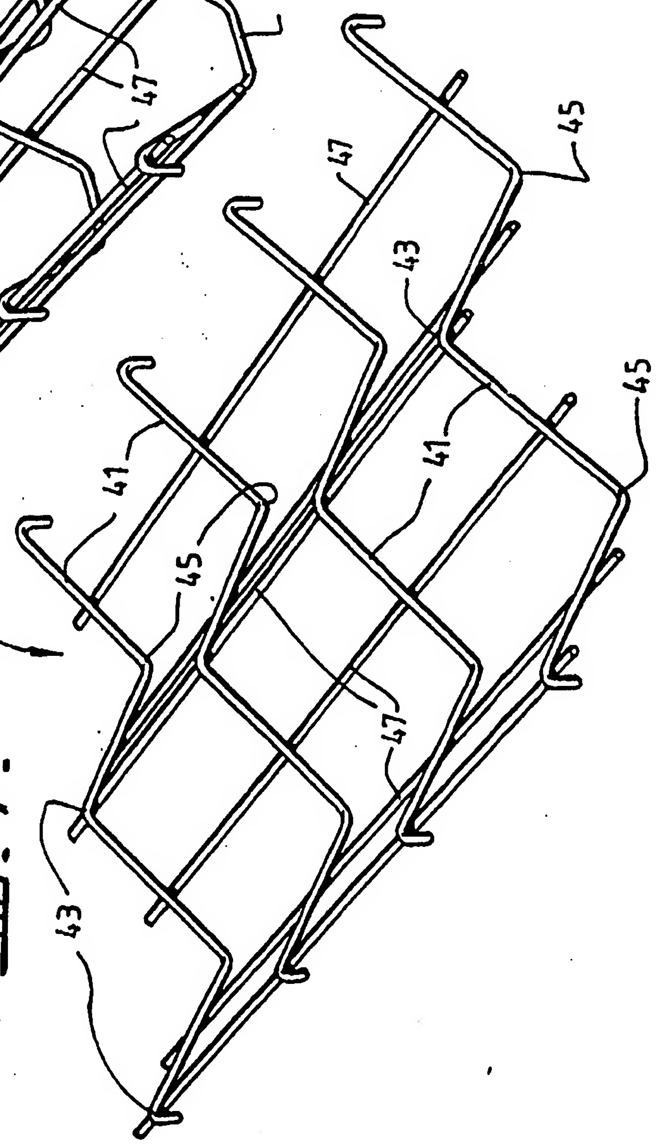
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FIG. 4.

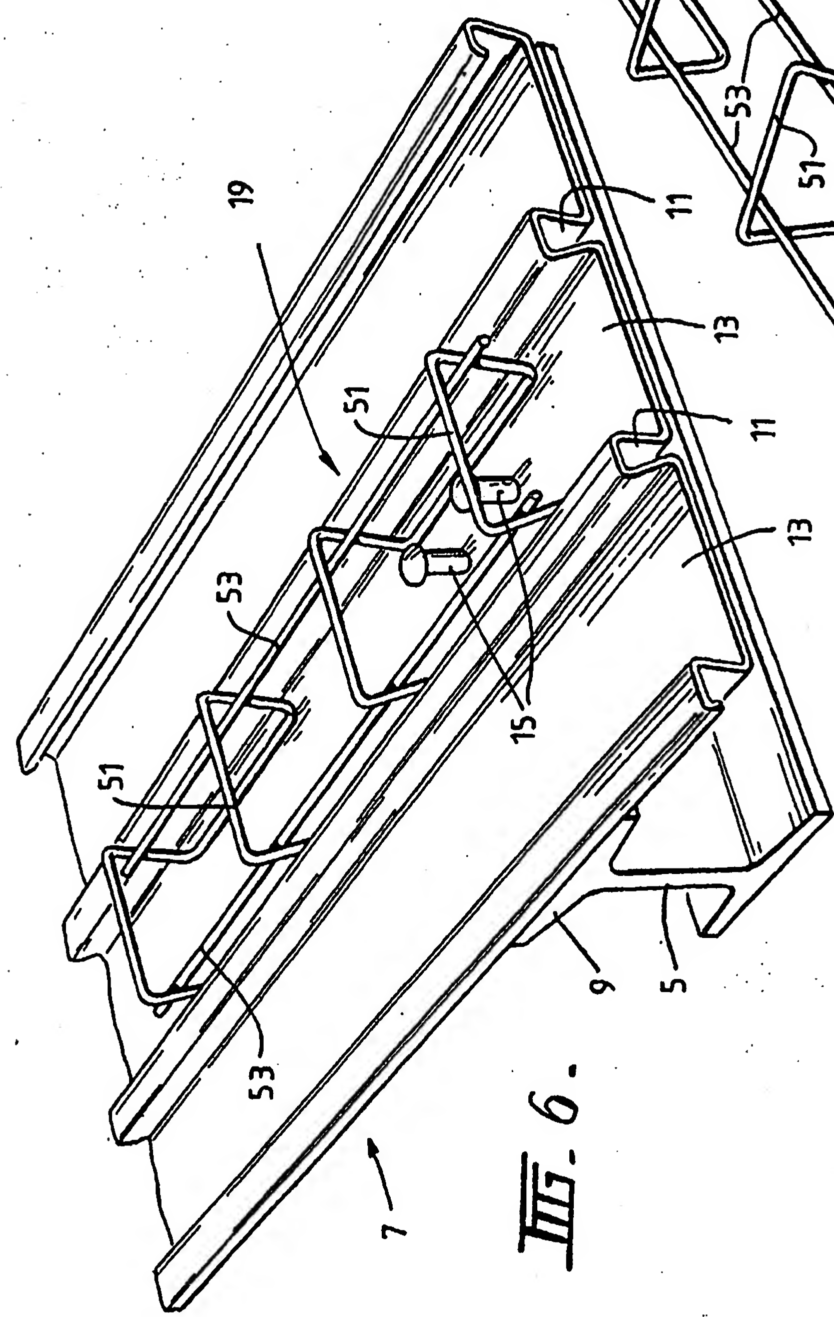

FIG. 6.

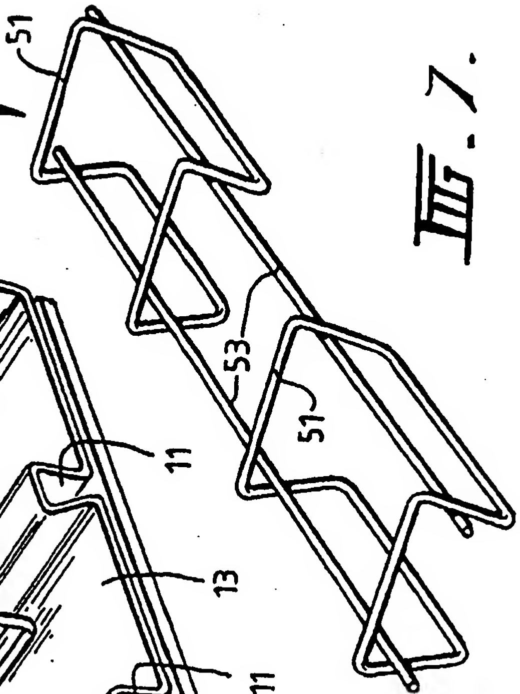

FIG. 7.